US005473376A

United States Patent [19]

Auyeung

[11] Patent Number: 5,473,376

[45] Date of Patent: Dec. 5, 1995

[54] **METHOD AND APPARATUS FOR ADAPTIVE ENTROPY ENCODING/DECODING OF QUANTIZED TRANSFORM COEFFICIENTS IN A VIDEO COMPRESSION SYSTEM**

[75] Inventor: **Cheung Auyeung**, Hoffman Estates, Ill.

[73] Assignee: **Motorola, Inc.**, Schaumburg, Ill.

[21] Appl. No.: **347,639**

[22] Filed: **Dec. 1, 1994**

[51] **Int. Cl.**[6] **H04N 7/26**; H04N 7/30

[52] **U.S. Cl.** **348/403**; 348/405; 348/404; 348/419; 348/420

[58] **Field of Search** 348/384, 395, 348/403, 405, 395, 404, 419, 420

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,633,296	12/1986	Cham et al.	348/403
5,038,209	8/1991	Hang	348/420
5,162,908	11/1992	Kim	348/403
5,253,055	10/1993	Civanlar et al.	348/419
5,272,528	12/1993	Juri et al.	348/403
5,282,031	1/1994	Kim	348/404
5,371,549	12/1994	Park	348/403
5,396,291	3/1995	Sanpei	348/403

OTHER PUBLICATIONS

"Coding of Moving Pictures and Associated Audio–For Digital Storage Media at up to about 1.5 Mbit/s–", CD 11172–2, Part 2 Video, Apr. 3, 1992.

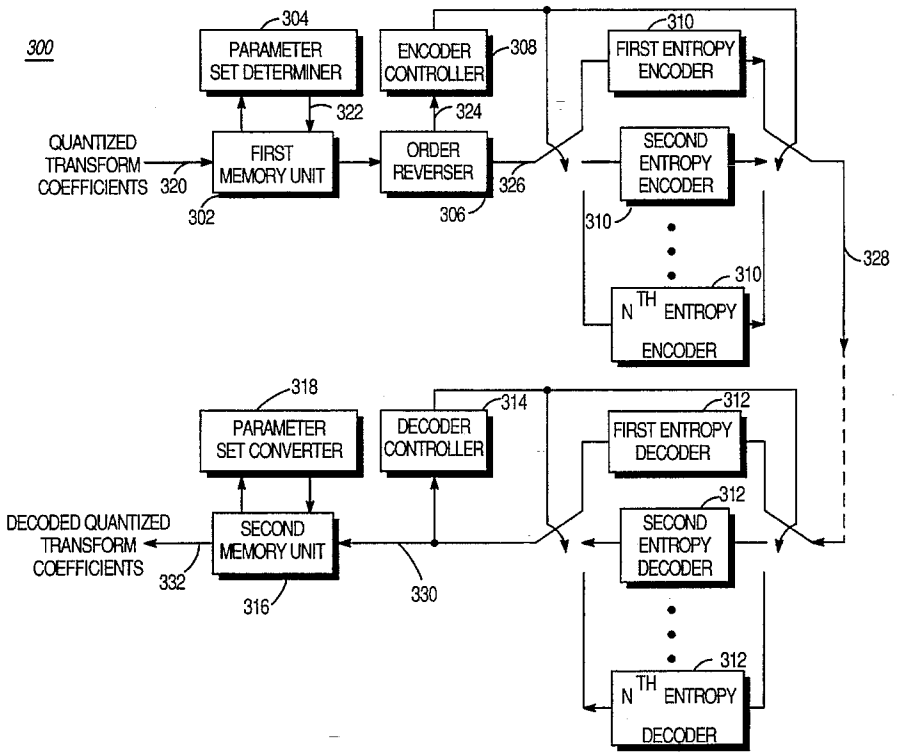
"Video Codec Test Model, TMN4", ITU Telecommunicaton Standardization Sector, Study Group 15, Working Party 15/1, LBC–94.

Primary Examiner—Tommy P. Chin
Assistant Examiner—Anand S. Rao
Attorney, Agent, or Firm—Darleen J. Stockley

[57] **ABSTRACT**

The present invention is a method (**100**) and apparatus (**300**) for adaptive entropy encoding/decoding of a plurality of quantised transform coefficients in a video/image compression system. For encoding, first, a predetermined number of quantized transform coefficients are received in a predetermined order, giving a generally decreasing average power. Then the quantized transform coefficients are parsed into a plurality of coefficient groups. When the last coefficient group comprises all zero quantized coefficients, it is discarded. The coefficient groups are then converted into a plurality of parameter sets in the predetermined order. A current parameter set is obtained from the parameter sets in the reverse order of the predetermined order. A current entropy encoder is selected adaptively based on the previously selected entropy encoder and the previous parameter set. The current parameter set is encoded by the current entropy encoder to provide entropy encoded information bits.

18 Claims, 3 Drawing Sheets



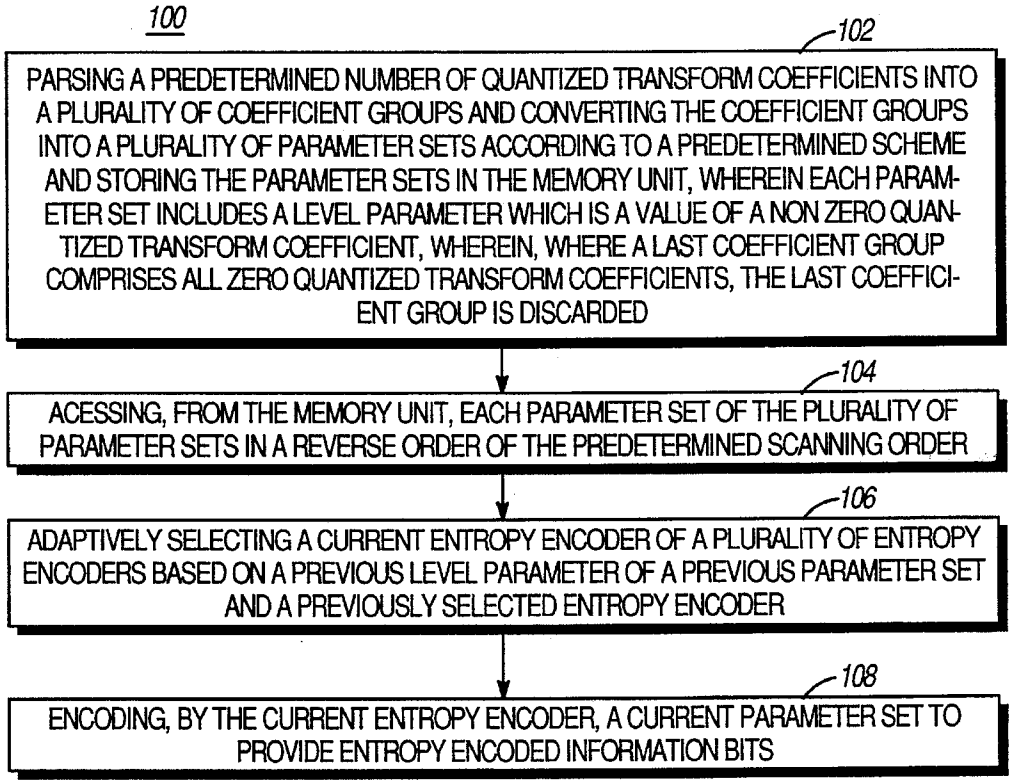


Fig.1

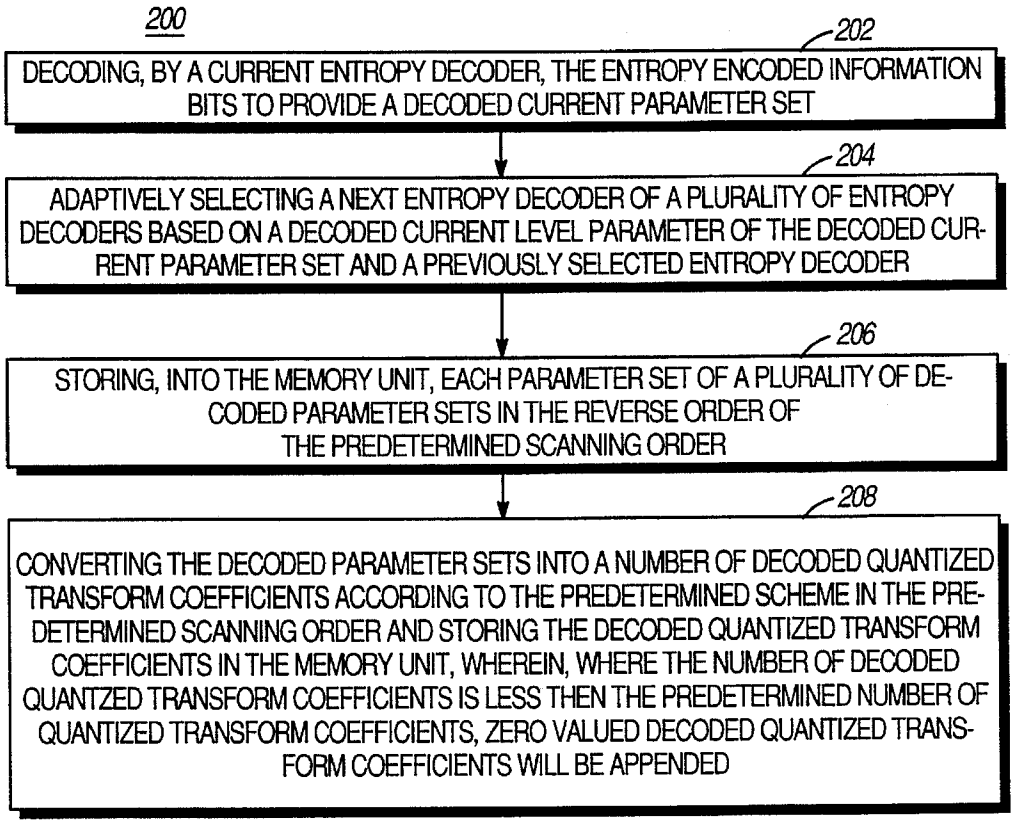


Fig.2

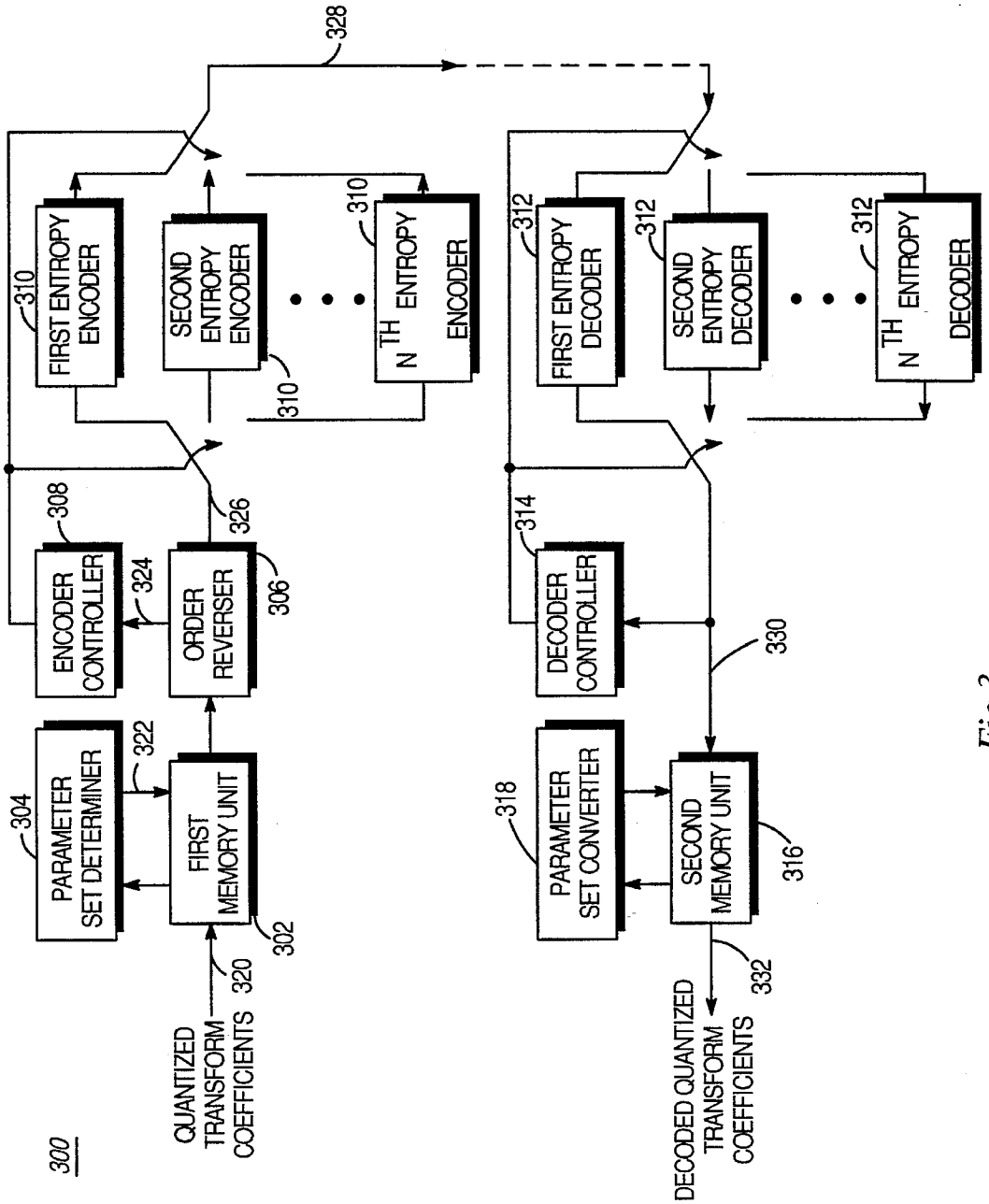


Fig.3

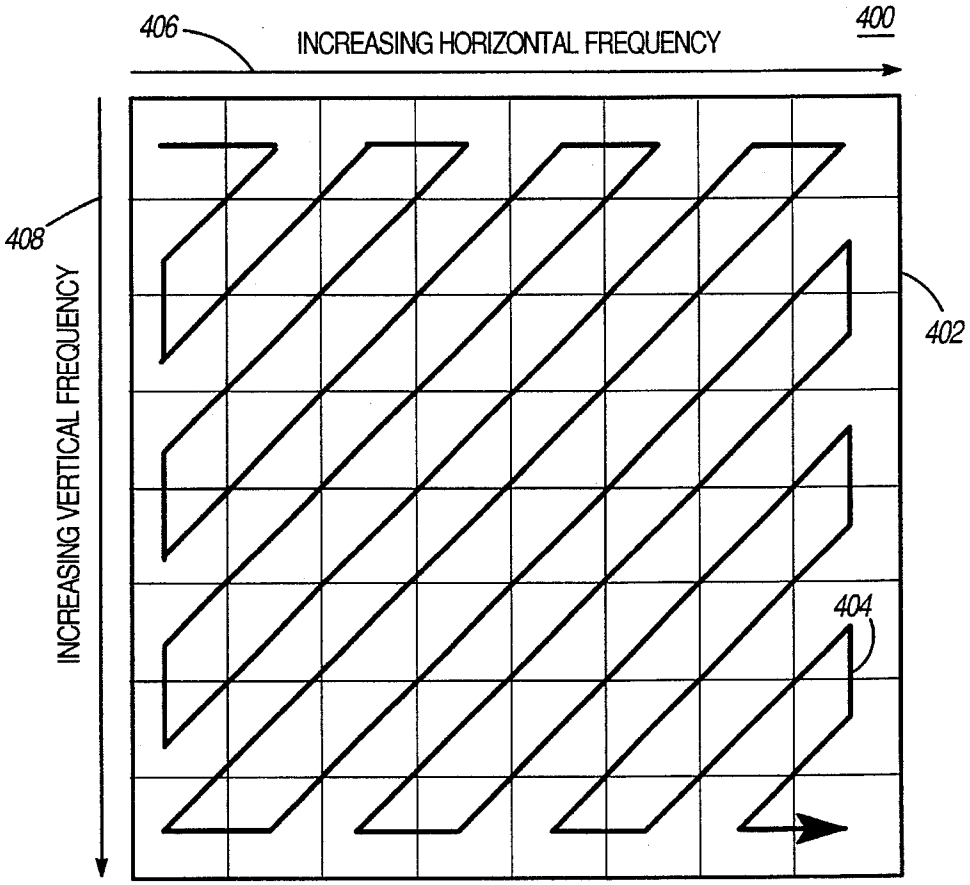


Fig.4

— PRIOR ART —

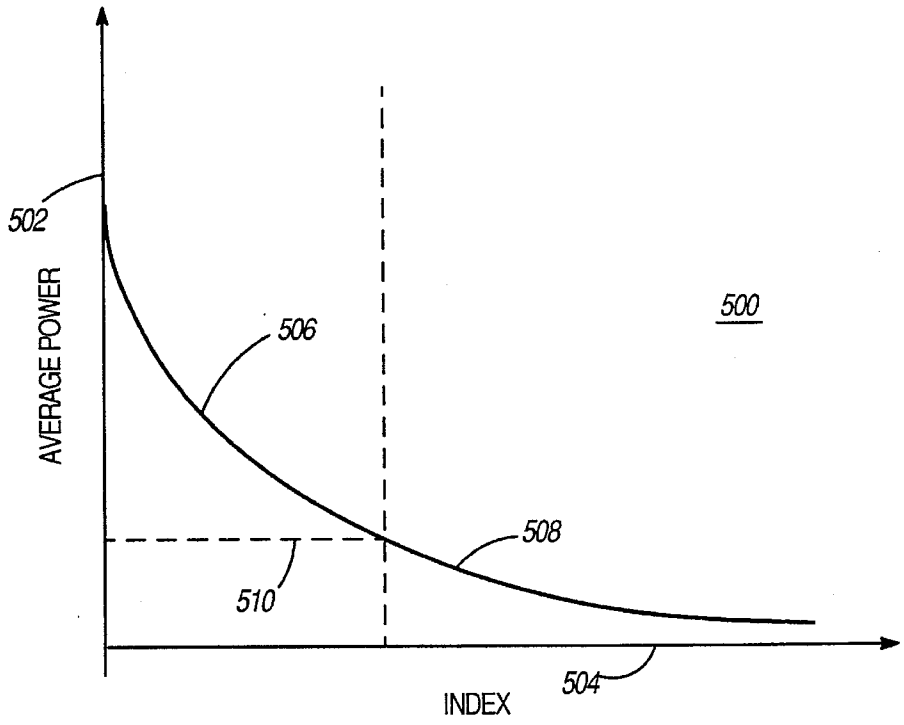


Fig.5

METHOD AND APPARATUS FOR ADAPTIVE ENTROPY ENCODING/DECODING OF QUANTIZED TRANSFORM COEFFICIENTS IN A VIDEO COMPRESSION SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates generally to the field of video compression, and in particular, to entropy coding.

2. Description of the Prior Art

Video systems are known to include a plurality of communication devices and communication channels, which provide the communication medium for the communication devices. For example, the communication channel may be wireline connections or radio frequency, RF, carriers. To increase the efficiency of the video system, video that needs to be communicated over the communication medium is digitally compressed. Digital compression reduces the number of bits needed to represent the video while maintaining perceptual quality of the video. The reduction in bits allows more efficient use of channel bandwidth and reduces storage requirements. To achieve digital video compression, each communication device may include an encoder and a decoder. The encoder allows a communication device to compress video before transmission over a communication channel. The decoder enables the communication device to receive compressed video from a communication channel and render it visible. Communication devices that may use digital video compression include high definition television transmitters and receivers, cable television transmitters and receivers, video telephones, computers and portable radios.

Several emerging standards for digital video compression are being developed, including International Telecommunications Union (ITU), ITU-T Recommendation H.26P, the International Standards Organization/International Electrotechnical Committee (ISO/IEC), and International Standard MPEG-4. These standards are likely to use transform coding as part of the building blocks for good coding efficiency. Currently, the Expert's Group on Very Low Bitrate Visual Telephony, LBC, is considering using the discrete cosine transform for coding efficiency. The Moving Pictures Expert's Group, MPEG, is also likely to use the discrete cosine transform or other type of transform. To achieve compression, the transform coefficients are quantized and entropy coded.

Therefore, to maximize the compression capability, a need exists for a method and apparatus for entropy coding the quantized transform coefficients more efficiently than the emerged standard H.261, MPEG-1, and MPEG-2, especially for low bit rate applications.

SUMMARY OF THE INVENTION

The present invention is a method and apparatus for adaptive entropy encoding/decoding of a plurality of quantized transform coefficients in a video/image compression system. For encoding, first, a predetermined number of quantized transform coefficients are received in a predetermined order, giving a generally decreasing average power. Then the quantized transform coefficients are parsed into a plurality of coefficient groups. When the last coefficient group comprises all zero quantized coefficients, it is discarded. The coefficient groups are then converted into a plurality of parameter sets in the predetermined order. A current parameter set is obtained from the parameter sets in the reverse order of the predetermined order. A current entropy encoder is selected adaptively based on the previously selected entropy encoder and the previous parameter set. The current parameter set is encoded by the current entropy encoder to provide entropy encoded information bits.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a flow diagram of steps for one embodiment of a method for adaptive entropy encoding in accordance with the present invention.

FIG. **2** is a flow diagram of steps for one embodiment of a method for adaptive entropy decoding in accordance with the present invention.

FIG. **3** is a block diagram of one embodiment of an apparatus for adaptive entropy encoding/decoding in accordance with the present invention.

FIG. **4** is an exemplary prior art illustration of a method of scanning and transforming a two dimensional block to provide a one dimensional array of scanned coefficients.

FIG. **5** is a graphical depiction of the average power, in general, of the scanned coefficients with respect to the index; a distinction between lower and higher power coefficient is made in accordance with the present invention.

DESCRIPTION OF A PREFERRED EMBODIMENT

The present invention is a method and an apparatus for adaptive entropy encoding/decoding of a plurality of quantized transform coefficients in a video/image compression system. For encoding, first, a predetermined number of quantized transform coefficients are received in a predetermined order giving a generally decreasing average power. Then the quantized transform coefficients are parsed into a plurality of coefficient groups. When a last coefficient group comprises all zero quantized coefficients, the last coefficient group is discarded. The coefficient groups are then converted into a plurality of parameter sets in the predetermined order. A current parameter set is obtained from the parameter sets in the reverse order of the predetermined order. A current entropy encoder is selected adaptively based on the previously selected entropy encoder and the previous parameter set. The current parameter set is encoded by the current entropy encoder to provide entropy encoded information bits.

This invention may be used with a compression algorithm that processes a picture into two-dimensional blocks of quantized transform coefficients with predetermined transform sizes. Each block is then scanned into a one-dimensional array in a predetermined order giving generally decreasing average power.

The one-dimensional array of quantized transform coefficients are parsed into a sequence of coefficient groups as shown by the following example. For example, consider an array having 64 coefficients, only five of which are non-zero:

$$\{0,0,1,0,-2,3,0,1,0,0,1,0,0,\ldots\} \quad (1)$$

After parsing, the coefficient groups are

$$\{0,0,1\},\{0,-2\},\{3\},\ \{0,1\},\{0,0,1\}. \quad (2)$$

In general, the number of coefficient groups is the same as the number of non-zero coefficients since the last group {0,

DOCKET ALARM

Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts

Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research

With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips

Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS
Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS
Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS
Sync your system to PACER to automate legal marketing.